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The office work and stretch training (OST) study: Effects on the prevalence of musculoskeletal diseases and gender differences

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Abstract

Objectives. For the prevention of musculoskeletal diseases, stretch training can be a measure of the workplace health promotion for office workers. This can lead to an increase in mobility and, ultimately, improve or prevent MSD. The aim of the study was to examine a standardized and individualized stretch training on a device, specifically “five-Business”, for the prevalence of MSD.

Methods. 252 (110 females; 142 males) subjects (median age of 44 ($\tilde{X}21$) years) were included in this study. The intervention group completed 22-24 training units on the “five-Business” device twice a week for 12 weeks. Data were collected in the form of a pre-post study Nordic Questionnaire.

Results. After the intervention, significantly fewer subjects reported pain in the area of the neck (-17.79%), shoulders (-11.28%), upper back (-14.7%), lower back (-12.78%) and feet (-8.51%). The gender analysis revealed that women are, in general, more often affected by musculoskeletal complaints than men, especially in the neck (+29.5%) and feet (+15.03%). Both sexes had significant reductions of MSD in the most commonly affected regions. Thus, 27.12% less females reported having neck pain, while 13.14% less males reported having low back pain.

Conclusions. The results suggest that a stretching programme performed for three months can reduce musculoskeletal complaints in the most commonly affected areas in office workers. Both men and women benefited from the stretch training to a similar extent, suggesting that this would be a promising measure for therapy and prevention as part of workplace health promotion.

Keywords: workplace health promotion, stretch training, musculoskeletal diseases, incapacity to work, flexibility, office work, five-Business, Five-Konzept, seated workplaces, Nordic Questionnaire

'Article summary'

'Strengths and limitations of this study'

- This is the first study to observe genderspecific effects of a stretch training intervention on musculoskeletal diseases in office workers.
- 252 office workers of the automobile industry completed a three-months stretch training intervention-control study during working hours.
- Three sports scientists/physiotherapists accompanied and controlled each training unit, however, such an intensive supervision is not feasible in the everyday work life.
- A randomized allocation was not applicable, since subjects had to arrange training in accordance with business appointments and holidays.

Introduction

Musculoskeletal diseases (MSD) are a common health hazard among office workers in industrial nations[1]. Around 50% of employees suffer from moderate pain in the back and neck, while 30% complain of severe pain[2]. MSD play a decisive role in job absenteeism[3], presenteeism[4], reduced quality of life[3] and the incidence of work-related injuries[5]. In Germany, MSD are the main cause of disability days (20.9%), followed by sickness of the respiratory system (16.0%) and mental illness (15.2%)[6]. In addition, MSD is the diagnosis which leads to the most downtime costs (17.2 billion €)[7]. On average, disability due to MSD lasts for 19.7 days, with men being affected more frequently than women[8]. Occupational risk factors, such as repetitive and static work, poor psychological and social conditions are related, in particular, to neck/shoulder pain and low back pain[9 10].

Employers have reacted to this by implementing workplace health promotion (WHP) measures to help keep staff healthy. However, in heterogeneously composed staff, WHP are potentially not suited for every individual employee. For example, MSD occur differently in men and women; while women show, generally, a higher prevalence of clinical pain conditions, some specific pain conditions are more common in men[11]. This is especially the case in the upper extremities area where women appear to suffer more often from musculoskeletal complaints than men[12]. While neck and shoulder pain are also predominantly found in women, only small gender differences have been reported in the majority of epidemiological pain research on low back pain[10]. However, literature on the topic is controversially discussed; while some studies have found an increased prevalence in women[13 14], others have shown an increase in men[15 16] and, furthermore, other studies have found no gender- specific differences[17-19].

One reason for this lack of clarity might be that causes for MSD are multifactorial, for which awareness has risen in recent years[20]. Often both psychological and postural demands contribute to the development of MSD. Increasing competition and rising productivity requirements lead to increased pressure to meet deadlines and to perform[20], while the main working time is spent in offices in a static sitting position in front of a computer[21]. Both of these demands can lead to unphysiological tension of the musculature and, ultimately, contribute to restrictions in mobility[22].

Amongst other methods, such as resistance training, stretch trainings are a promising WHP approach, for which van Eerd et al.[23] found moderate evidence in a systematic review. The primary aim of stretch interventions is to improve mobility and, ultimately, to improve or prevent MSD. This was demonstrated, for example, in an investigation by Shariat et al.[24] who compared a stretch intervention to ergonomic adjustments in the office by means of the Cornell Musculoskeletal Disorders Questionnaire. While after four months' intervention time, both methods led to improvements in MSD (pain prevalence) in the lower back, shoulders and the

neck, after six months' intervention time, this improvement was only present in those subjects who had executed the stretching program.

However, the body of literature regarding stretching intervention for office workers is rather small as the subject is not, as yet, extensively studied[25]. For example, the programs investigated so far have scarcely been standardized and have not been individualized[24 26].

Therefore, the aim of the present intervention control study with the "five-Business" training ("Five Konzept", Hüfingen, Germany) is to evaluate a standardized and, at the same time, individualized stretch program by means of the Nordic Questionnaire (NQ). In addition, existing gender differences and gender-specific effects of the intervention should be identified. This study is part of the OST project, which, in addition to MSD, investigates the effects of the "five-Business" program on the quality of life and mobility of office workers.

Methods

Subjects

Subjects were recruited among 1958 clerical employees of a German car manufacturer. In total, 313 participants (males: n=172; females: n=137) aged between 18 and 65 years volunteered to take part in the intervention control study. Of these, 216 were allocated to the intervention group (IG) and 97 to the waiting control group (KG). A total of 252 participants successfully completed the study, while 61 subjects dropped out (IG=60; CG=1). A detailed description of the sample is given in Table 1.

Tab. 1: Sociodemographic data of the entire sample. SD=standard deviation; IQR=interquartile range. The descriptive statistic is based on the data of the "final participants".

	Entire sample			**Intervention group**			**Control group**		
		male	female		male	female		male	female
Initial participants	n=313	n=172	n=137	n=216	n=135	n=78	n=97	n=42	n=55
Dropouts	n=61	n=36	n=27	n=60	n=34	n=23	n=1	n=1	n=0
Final participants	n=252	n=142	n=110	n=156	n=101	n=55	n=96	n=41	n=55
Age (years) median (IQR)	44 (21)	49 (15)	38 (21)	46,5 (17)	49 (14)	38,5 (22)	43 (23)	45 (22)	37 (18)
Height (cm) mean (SD)	175.3 ±9.4	180.4 ±7.4	168.8 ±7.5	176.2 ±8.7	180.7 ±9.5	167.9 ±6.3	173.9 ±10.4	179.9 ±9.9	169.6 ±12.4
Weight (kg) median (IQR)	76 (21)	82 (15)	65 (12.8)	77.5 (18)	82 (14)	65 (17.5)	71 (23)	82 (17.5)	65 (11.3)
BMI (kg/m^2) median (IQR)	24.07 (4.32)	24.79 (3.95)	23.12 (4.09)	24,34 (4.79)	24.93 (4.11)	23.12 (4.97)	23.53 (3.43)	24.57 (3.41)	23.10 (3.58)
Sports (% yes/% no)	71.8/ 27.4	71.8/ 27.5	71.8/ 27.3	71.2/ 28.8	70.3/ 29.7	72.7/ 27.3	72.9/ 25.0	75.6/ 22.0	70.9/ 27.3
Smoking (% non-smoker)	87.7	90	86.4	89.7	92.1	85.5	87.1	84.6	88.9
h/sports/week median (IQR)	3 (3)	3 (4)	2 (2)	2 (4)	2 (4)	2 (3)	3 (3)	4 (3)	3 (3)

The recruitment strategy consisted of an internal e-mail which was sent by the health department. Via an integrated link, employees could register for participation on a voluntary basis (Fig. 1); the registration deadline was set at two weeks. It was communicated that the training would be carried out during working hours and all participants were asked to pursue (only) their usual leisure activities during the intervention.

<Fig. 1>

Inclusion criteria included full-time employment in an office workplace, subjective health and freedom from exclusion criteria.

Exclusion criteria covered operations or surgical stiffening of the musculoskeletal system, relevant artificial joint replacement, serious diseases such as ankylosing spondylitis, chronic destructive joint diseases, multiple sclerosis, myodystrophic or neurodegenerative diseases,

congenital malposition of the musculoskeletal system or acute diseases such as a herniated disc. In addition, the intake of muscle relaxants or other medications that influence the elasticity of the muscles, as well as pregnancy, were considered contraindicators. Further information can be found in the related methodology article[28].

All test persons gave a written declaration of consent to participate in the study in advance. The study was approved by the Ethics Committee of the Medical Faculty of the Baden-Württemberg Medical Association (F-2017-073).

Patient and Public Involvement

There were no patients involved in this study.

Intervention program "five-Business"

The device-supported stretch training “five-Business” (Fig. 2) is a WHP measure provided by the company "Five-Konzept" (Hüfingen/Germany). All exercises can be carried out standing, wearing shoes and in loose working clothes. Subjects held the five stretching positions twice for 20 seconds each. Further descriptions can be found in the methodology paper by Holzgreve et al.[28].

<Fig. 2>

Nordic Questionnaire

The Nordic Questionnaire (NQ) records musculoskeletal complaints [9] and has been used internationally in a wide range of professions[29], including administrative professions [14]. The questionnaire asks for information about the person, their work situation and their 7-day, 12-month and lifelong prevalence of musculoskeletal complaints in the neck, shoulder, thoracic and lumbar spine and the joints of the extremities. The duration and frequency of the complaints, resulting impairments at work and participation in leisure activities, as well as physicians' consultations and incapacities to work, are recorded. The questionnaire was digitalized and completed online on site using computers provided for this purpose. The NQ was provided in German and socio-demographic questions were additionally included.

Measurement protocol

The data presented here represent a partial evaluation of a larger exploratory research project (OST) in which, in addition to MSD, the effects of the "five-Business" program on the health-related quality of life and mobility of office workers were investigated. Further details can be found in the related methodology article[28] and article on effects on the quality of life[27]. The intervention period covered 12 weeks, with data collection taking place in the week before and after the intervention. During these 12 weeks, the subjects in the IG completed a total of 22-24 stretch training sessions, where possible twice a week. In case of illness or holidays, absences of up to two weeks were granted, since this corresponds to the realistic conditions in everyday working life. The test persons were allowed to make up for the missed training sessions through a higher frequency of three training sessions per week. One training session lasted about ten minutes; each exercise was held twice for 20 seconds. The correct execution of the exercises was monitored by trained personnel via 1:2 supervisions. Progressive intensity was implemented by the trainers using the variable adjustment function of the device. If participants forgot their training dates, they were contacted and a catch-up date was arranged. In the waiting control group, the measurements were carried out analogous to the IG, but the subjects did not train on the “five-Business” device during the three months period. The NQ was applied at baseline and after three months.

Statistical analysis

IBM SPSS Statistics 26 were used to perform the Kolmogoroff-Smirnoff-Liliiefors test to asses the normal distribution of the socio-demographic data. In order to obtain descriptive data, either means or medians including standard deviations (SD) or interquartile ranges (IQR), respectively, were calculated. The statistics of the NQ measures were performed with BiAS (version 11.08), including only non-parametric methods, since the response options were dichotomized. For dependent comparisons, the McNemar test was performed. In order to test independent groups, the Chi^2 test with Yates-correction for case numbers <60 was used.

Results

In the entire sample at baseline the participants reported the most complaints for the last year in the areas of the neck (60.66%), shoulders (51.02%) and lower back (48.37%). More than a quarter of the participants stated that they had had complaints in the upper back (25.73%) and knees (26.42%) in the last year (Fig. 3).

<Fig. 3>

The calculations of the McNemar test showed that in the IG the proportion of participants with complaints in the neck ($p<0.001$), shoulders ($p<0.02$), upper back ($p<0.001$) and lower back ($p<0.01$) had significantly decreased post-intervention (Fig. 4). In the thighs (16.89% vs. 12.16%), the wrists/hands (17.57% vs. 13.33%) and the knees (33.55% vs. 26.67%), a non-significant trend of a reduction in complaints was observed (Fig. 4). For the CG, significant differences in pain prevalence could be detected in the neck after 12 weeks compared to the baseline ($p=0.41$). Moreover, a non significant reduction in complaints was evident in the area of the shoulders (42.11% vs. 36.46%), lower back (37.23% vs. 34.74%) and thighs (11.83% vs. 8.42%).

<Fig. 4>

Gender effects

With the exception of the elbow and lower back, female office workers showed a generally higher 12-month prevalence of musculoskeletal complaints at baseline (Fig. 5). Both male and female workers had the most complaints in the shoulder/neck area and in the lower back. In almost all areas and in both genders, musculoskeletal pain prevalences decreased after the intervention; this was especially observed in the most heavily affected regions where the employees seemed to benefit particularly from the intervention. It can also be seen that in almost every region, the pain prevalence rates of both sexes were converging. Gender specific significant differences were found for the neck area between baseline prevalences ($p<0.001$) and between baseline and post-intervention ($p<0.001$) in females. Further significant differences were found in the upper back area. Both males ($p=0.041$) and females ($p=0.007$) had significant reductions of complaints. Moreover, males had significantly ($p=0.011$) less back pain after the intervention. In addition, females reported at baseline significantly more often about foot complaints ($p=0.015$) than males (Fig. 5).

<Fig. 5>

Discussion

The aim of the study was to examine the effectiveness of the "five-Business" stretch training in reducing MSD concerning the 12-month prevalence among office workers. In addition, gender differences were also identified with regard to the research objective. The results showed a significant reduction in the 12-month prevalence of MSD, following a 3-month stretch training program, in the area of the neck, shoulders, upper and lower back and the feet (Fig. 4) in the treatment group. Since these were also the body parts most affected in the baseline results, the reduction in complaints occured in exactly those areas that are exposed to risk factors for MSE from sedentary and static activities[9 10] (Fig. 3 & 4).

The prevalences found are in line with current literature[3 30-32] investigating MSD among office workers. Kalieniene et al.[31] found neck pain in 65.7%, shoulder pain in 50.5% and low back pain in 56.1% in a sample of public service computer workers in Lithuania; a similar distribution of complaints was shown in Australian office workers with prevalences of 76% (neck), 71% (shoulders) and 65% (lower back)[30]. Less complaints, but similar affected areas, have been reported in office workers in Bangladesh[3] and Iran[32].

Regarding the stretch trainings as a method to reduce MSD, the few previous studies confirm the current findings[23 25 33]. For example, Tunwattanapong et al.[26] conducted a daily neck and shoulder stretching program for four weeks in office workers with moderate to severe neck or shoulder pain. The treatment group showed a significant decrease in neck and shoulder pain and an improvement in neck function and in the physical dimensions of the SF-36 questionnaire. Similar results have been shown in the present study since, here too, especially in the neck and shoulder area, the treatment group showed great improvements (Fig. 4).

Furthermore, the positive effects on low back pain are also supported by the findings of Lawand et al.[34], who showed significant improvements in pain, function and some quality of life aspects in patients with chronic low back pain. In this randomized controlled trial, subjects performed a weekly 60-minute stretching program, according to the global postural re-education method, over 12 weeks. The intervention period is similar to this study, but with longer stretching sessions. However, in the current study, significantly less office workers reported pain in the lower back area (12.78%).

The results of the current study also showed significant reductions of pain prevalence in the upper back and feet, with reduction trends observed in the wrists, thighs and knees, indicating that this whole body stretching program is effective in most areas of the body.

In the control group no difference between baseline and post was observed, except for the neck area ($p<0.05$). This unspecific effect may be due to various reasons; for example, the company's appreciation of the employees or the fact that skilled trainers took care of the particpants may have led to this.

Gender-specific significant differences were obtained at baseline in the area of the neck (f: 86.62% vs. m: 57.29%) and the feet (f: 25.45% vs. m: 10.42%) with significant treatment effects observed among males in the upper and lower back and among females in the neck and lower back, respectively (Fig. 5).

Fundamentally, the results show that women are more likely to report having MSD than men which is in line with the existing evidence[11]; this is especially noticeable in the neck (+29.5%), shoulder (+12.73%) area and upper back (+11.59%) where women seem to be more frequently affected than men (Fig. 5). These results confirm the contemporary literature that upper extremities MSD and neck/shoulder pain are predominantly found in women[12]. The exception to this point is the lower back, with 9.53% more men affected. According to the current state of knowledge, the evidence is unclear concerning gender-specific differences[10]. In principle, employees seem to benefit particularly in the regions that are most affected. According to this, women benefit particularly in the neck ($p<0.001$) and men in the lower back ($p<0.05$). In both groups, a significant reduction in upper back complaints ($p<0.05$ in males, $p<0.01$ in females) was also observed. In the area of the shoulders, which was frequently reported, a clear trend can be seen in both sexes (-9.22% in males, -14.81% in females). It is particularly striking that both the significant regions and the trends after the intervention appeared to be converging. In summary, it can be stated that women in the office workplace generally suffer more frequently from MSD. However, both men and women benefited from the stretching program.

The study results showed that a device-supported standardized and individualized stretch training is suitable as a WHP measure. Future studies should continue to investigate whether a reduction in the days of incapacity to work can be achieved in the long term by using this stretch training program.

When interpreting the presented results, the lack of randomization has to be taken into account. However, we preferred an allocation based on availability in order to recruit a large number of participants. Since subjects had to arrange training in accordance with business appointments and holidays, randomization would have threatened the feasibility of this study. This also explains the differences in the group size and gender distribution between the intervention and control groups. Furthermore, it has to be emphasized that the participants were guided by experienced trainers throughout the three months' intervention time. The trainers also arranged new training appointments if subjects missed their session. It is doubtful that participation would have been sufficiently regular without the personal supervision of a trainer. In the framework of the OST project Holzgreve et al.[27] could already show that the stretching intervention has relevant effects on the quality of life. In particular, strong effects were found in the psychological component of the quality of life. With regard to the main causes (MSD and mental illness) of sick leave in Germany, the "five-Business" program seems to be

a suitable measure for prevention and therapy in the context of health promotion for office workers.

Future studies should aim to implement a follow-up evaluation in order to investigate whether the stretch training can reduce MSD and days of incapacity to work in the long term and evaluate the effects of different intervention periods and training frequencies.

Conclusion

The results suggest that a stretching program performed for three months can reduce musculoskeletal complaints in the most affected areas in office workers. Both men and women benefited from the stretch training to a similar extent. Concerning the ubiquitous prevalence of MSD in office workers, especially shoulder/neck pain, upper back pain and lower back pain, the stretch program is proposed to be a promising measure for the therapy and prevention of MSD as part of workplace health promotion.

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Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Medical Faculty of the Baden-Württemberg Medical Association (F-2017-073). All participants signed an informed consent to participate in advance, so the consent was written. Minors were excluded as participants of this study.

Consent to publish

Not applicable.

Availability of data and materials

No additional data available.

Competing interests

None declared.

Funding

No funding was obtained for this study.

Cohort Description

Patients were not involved in this study.

Author's contribution

A.v.M., H.S., M.F., A.B. and D.O. conceived the original idea.

A.v.M., D.O., F.H., L.M. and J.H. conceived and planned the experiments.

F.H., L.M. and J.H. carried out the experiment.

D.O., A.v.M., D.A.G., H.S., A.B. and M.F. helped supervise the Project.

F.H. wrote the manuscript with support from L.M., D.A.G., A.v.M. and D.O.

All authors discussed the results and contributed to the final manuscript.

Figure legends

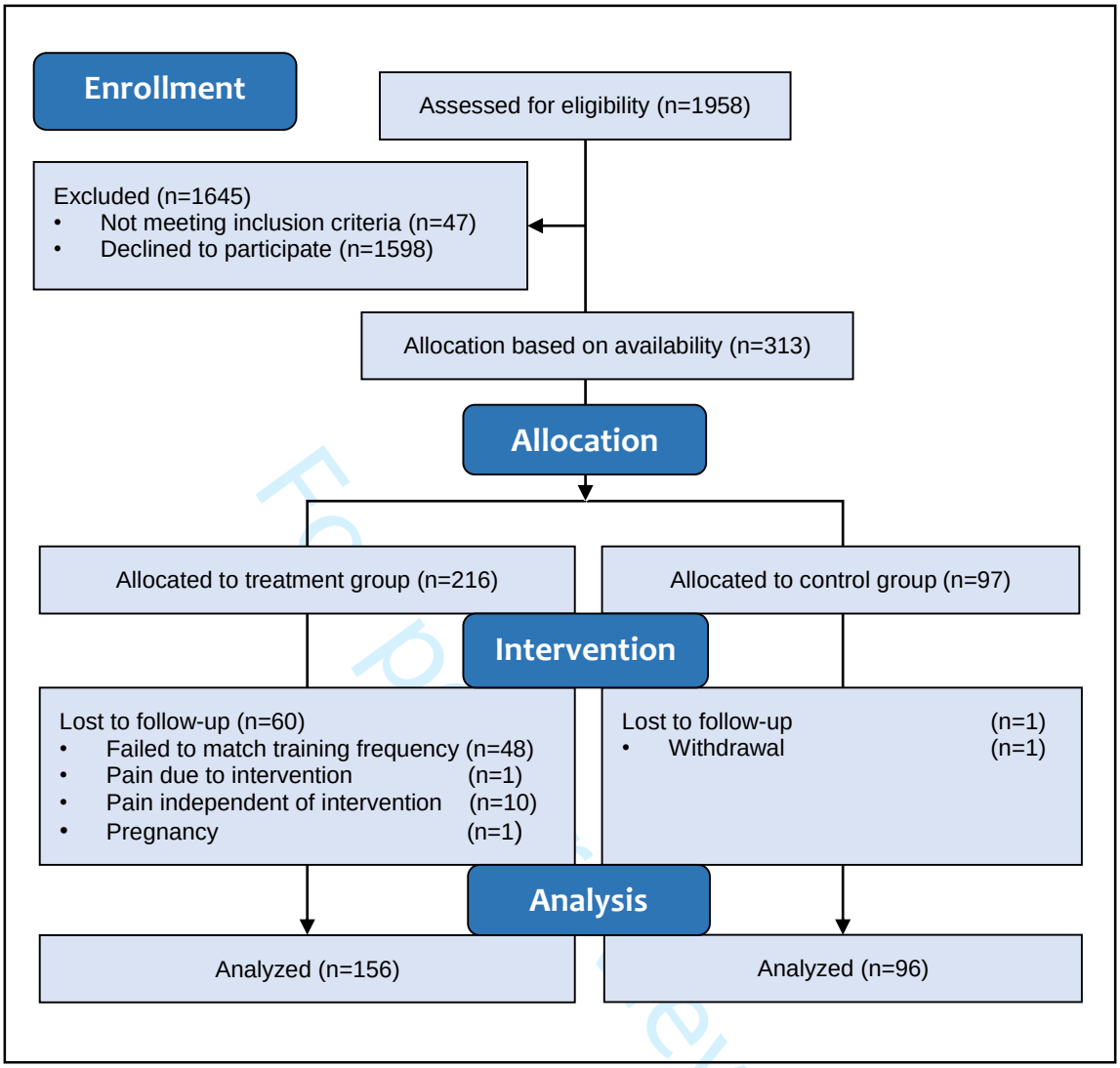
Fig. 1: Disposition of study participants. Modified after Holzgreve et al. 2020[27]

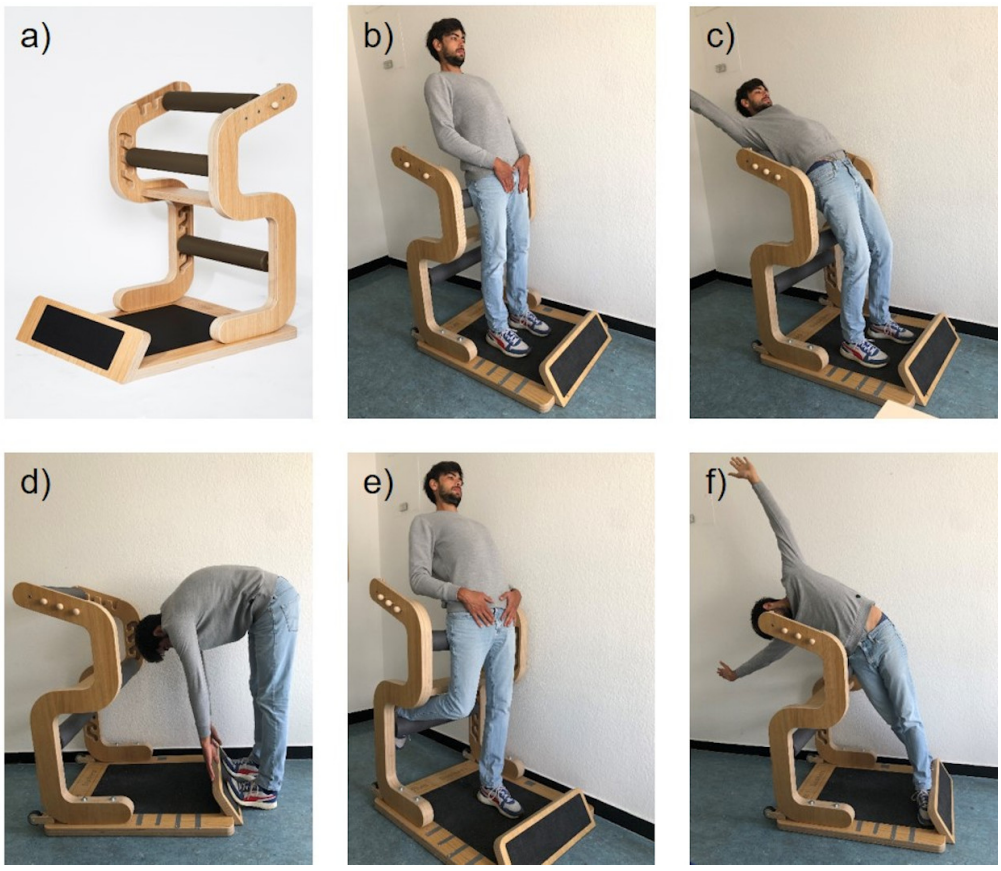
Fig. 2: "The stretch training on the "five-Business" device. a) The device with the dimensions: 116 cm x 82 cm x 128 cm; weight: 60 kg, b) Exercise "Stand", c) Exercise "Chest", d) Exercise "Ischio", e) Exercise "Hip" and f) Exercise "Lateral".

Fig. 3: 12-month prevalences of MSD in [%] of the entire sample at baseline.

Fig. 4: Pre-post comparison of the 12-month prevalence of MSD in [%] in the intervention and control groups**.** IG = intervention group; CG = control group. Significant differences are marked with asterisks for $p<0.05$ = "*", $p<0.01$ = "**" and $p<0.001$ = "***".

Fig. 5: 12-month prevalence of MSD in [%] at baseline and after intervention, according to gender, for the neck, shoulder, elbow, wrist, upper back, lower back, hip, knee and foot area. Significant differences are marked with asterisks ($p<0.0$ = "*", $p<0.01$ = "**" and $p<0.001$ = "***"). For dependent variables, the NcNemar test was applied; for independent variables, Chi^2 with Yates-correction for $n<60$ was used.





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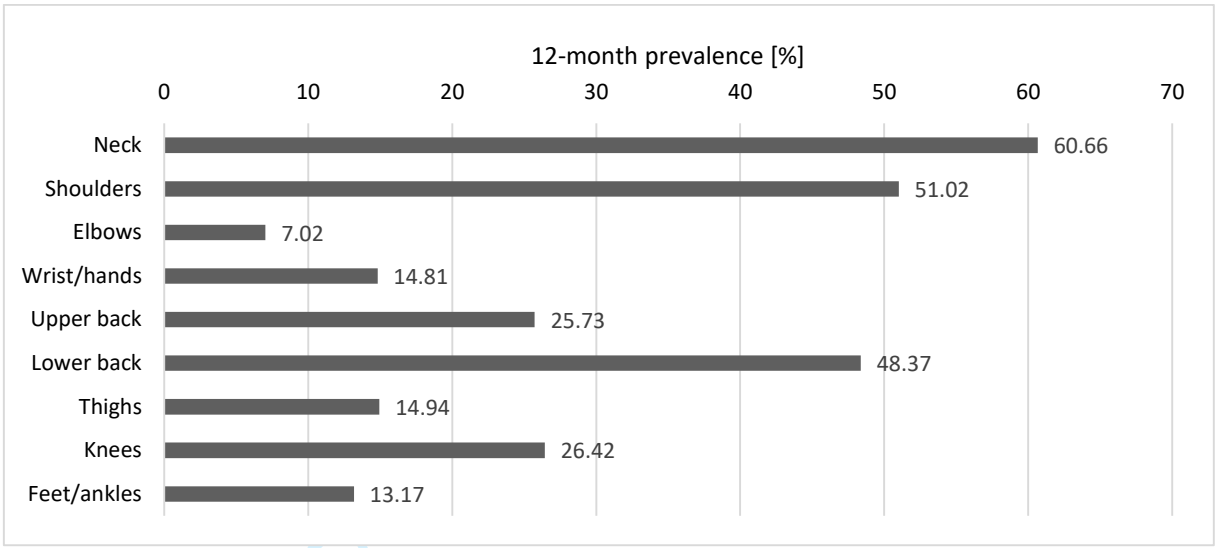

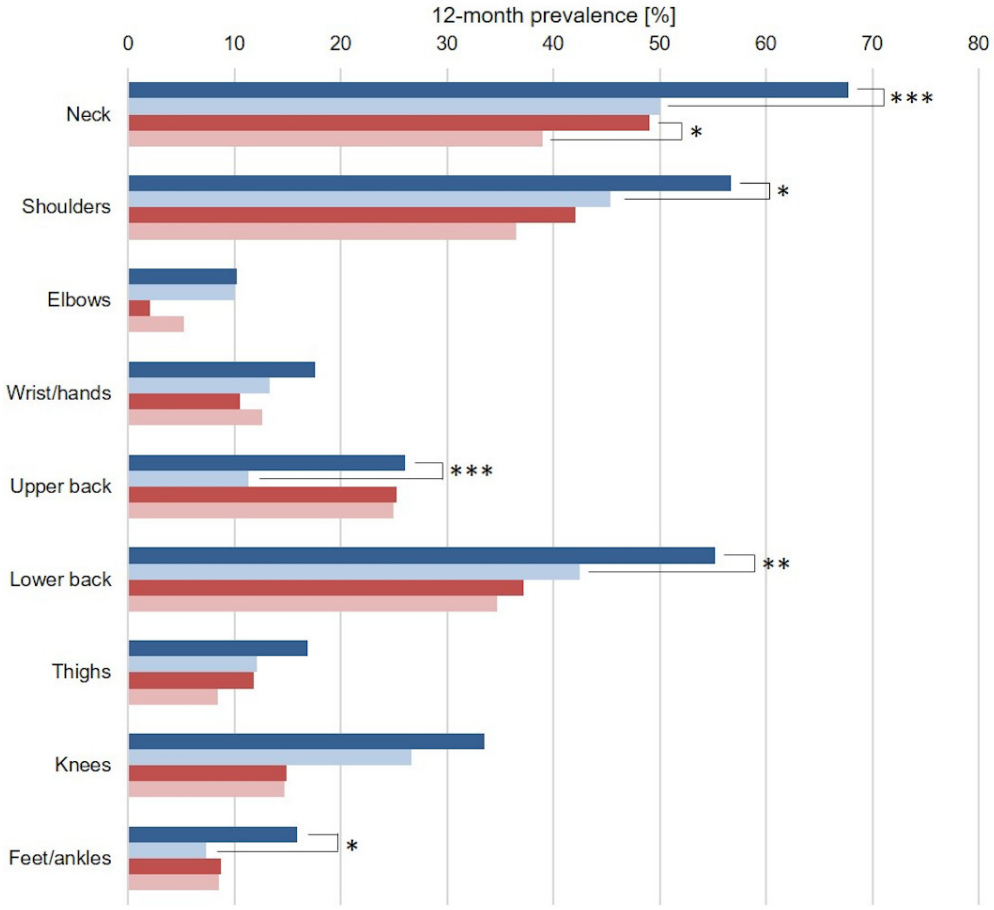

	Neck	Shoulders	Elbows	Wrists/hands	Upper back	Lower back	Thighs	Knees	Feet/ankles
IG_baseline	67.79	56.67	10.20	17.57	26.03	55.26	16.89	33.55	15.89
IG_post	50.00	45.39	10.00	13.33	11.33	42.48	12.16	26.67	7.38
CG_baseline	49.00	42.11	2.11	10.53	25.26	37.23	11.83	14.89	8.70
CG_post	39.00	36.46	5.21	12.63	25.00	34.74	8.42	14.74	8.51

Fig. 4: Pre-post comparison of the 12-month prevalence of MSD in [%] in the intervention and control groups. IG = intervention group; CG = control group. Significant differences are marked with asterisks for $p<0.05$ = "*", $p<0.01$ = "**" and $p<0.001$ = "***".

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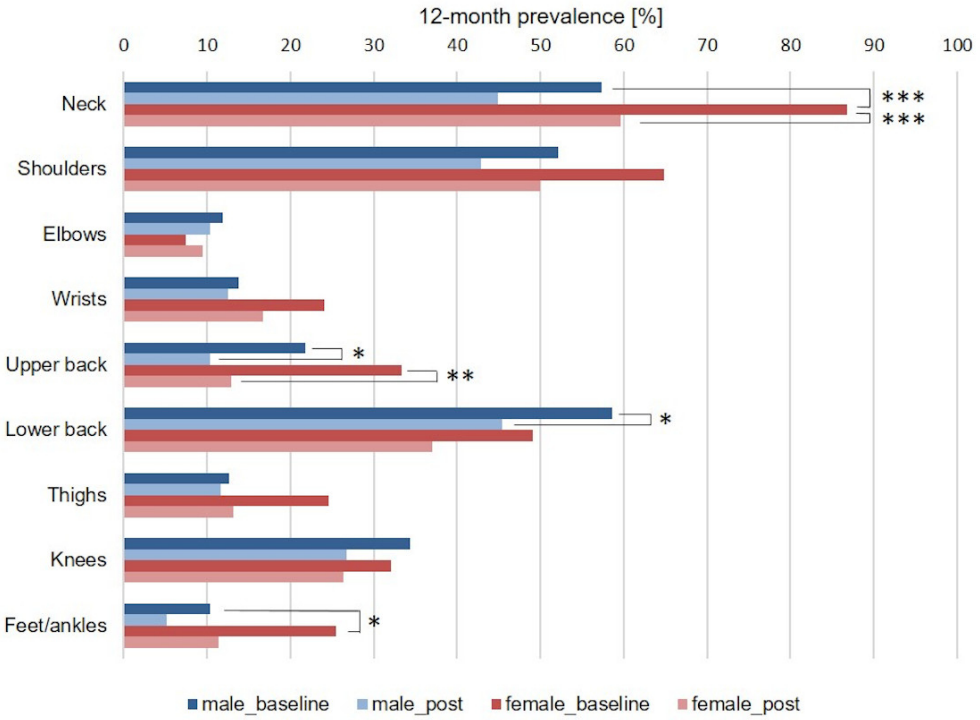

	Neck	Shoulders	Elbows	Wrists/hands	Upper back	Lower back	Thighs	Knees	Feet/ankles
male_baseline	57.29	52.08	11.83	13.83	21.74	58.59	12.63	34.34	10.42
male_post	44.90	42.86	10.31	12.50	10.42	45.45	11.58	26.80	5.21
female_baseline	86.79	64.81	7.41	24.07	33.33	49.06	24.53	32.08	25.45
female_post	59.62	50.00	9.43	16.67	12.96	37.04	13.21	26.42	11.32

Fig. 5: 12-month prevalence of MSD in [%] at baseline and after intervention, according to gender, for the neck, shoulder, elbow, wrist, upper back, lower back, hip, knee and foot area. Significant differences are marked with asterisks (p<0.0 = "*", p<0.01 = "**" and p<0.001 = "***"). For dependent variables, the NcNemar test was applied; for independent variables, Chi2 with Yates-correction for n<60 was used.

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The office work and stretch training (OST) study: Effects on the prevalence of musculoskeletal diseases and gender differences - A non-randomized control study.

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The office work and stretch training (OST) study: Effects on the prevalence of musculoskeletal diseases and gender differences - A non-randomized control study.

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Abstract

objectives: For the prevention of musculoskeletal diseases (MSD), stretch training can be a measure of the workplace health promotion for office workers. This can lead to an increase in mobility and, ultimately, reduce or prevent MSD. The aim of the study was to examine a standardized and individualized stretch training on a device, specifically “five-Business”, for the prevalence of MSD.

design: This study is a non-randomized control study.

setting: Workplace health promotion program with clerical employees of a German car manufacturer.

participants: 252 (110 females; 142 males) subjects (median age of 44 ($\tilde{X}21$) years) finished the study successfully. Inclusion criteria included a full-time employment in the office workplace and subjective health.

intervention: The intervention group completed 22-24 training units of 10 minutes each on the “five-Business” device twice a week for 12 weeks.

primary and secondary outcome measures: Data were collected in the form of a pre-post study Nordic Questionnaire.

results: After the intervention, significantly fewer subjects reported pain in the area of the neck (-17.79), shoulder (-11.28%), upper back (-14.7%), lower back (-12.78%) and feet (-8.51%). The gender analysis revealed that women are, in general, more often affected by musculoskeletal complaints than men, especially in the neck (+29.5%) and feet (+15.03%). Both sexes had significant reductions of MSD in the most commonly affected regions. Thus, 27.12% less females reported having neck pain, while 13.14% less males reported having low back pain.

conclusions: The results suggest that a stretching programme performed for three months can reduce musculoskeletal complaints in the most commonly affected areas in office workers. Both men and women benefited from the stretch training to a similar extent, suggesting that this would be a promising measure for therapy and prevention as part of workplace health promotion.

Keywords: workplace health promotion, stretch training, musculoskeletal diseases, incapacity to work, flexibility, office work, five-Business, Five-Konzept, seated workplaces, Nordic Questionnaire

'Article summary'

'Strengths and limitations of this study'

- This study reflects realistic working conditions with the involvement of the works council within the framework of the employees' working hours on a voluntary basis.
- The use of a waiting control group offered evey employee the same opportunity to participate in the treatment.
- Office workers stretched twice per week for 10 minutes each on the “five-Business” device, which was designed specifically for the application in the office.
- Three sports scientists/physiotherapists accompanied and controlled each training unit, however, such an intensive supervision is not feasible in the everyday work life.
- 1958 office workers were invited to particiape in this study, only 313 (16%) took finally part.

Introduction

Musculoskeletal diseases (MSD) are a common health hazard among office workers in industrial nations[1]. Around 50% of employees suffer from moderate pain in the back and neck, while 30% complain of severe pain[2]. MSD play a decisive role in job absenteeism[3], presenteeism[4], reduced quality of life[3] and the incidence of work-related injuries[5]. In Germany, MSD are the main cause of disability days (20.9%), followed by sickness of the respiratory system (16.0%) and mental illness (15.2%)[6]. In addition, MSD is the diagnosis which leads to the most downtime costs (17.2 billion €)[7]. On average, disability due to MSD lasts for 19.7 days, with men being affected more frequently than women[8]. Occupational risk factors, such as repetitive and static work, poor psychological and social conditions are related, in particular, to neck/shoulder pain and low back pain[9 10].

Employers have reacted to this by implementing workplace health promotion (WHP) measures to help keep staff healthy. However, in heterogeneously composed staff, WHP are potentially not suited for every individual employee. For example, MSD occur differently in men and women; while women show, generally, a higher prevalence of clinical pain conditions, some specific pain conditions are more common in men[11]. This is especially the case in the upper extremities area where women appear to suffer more often from musculoskeletal complaints than men[12]. While neck and shoulder pain are also predominantly found in women, only small gender differences have been reported in the majority of epidemiological pain research on low back pain[10]. However, literature on the topic is controversially discussed; while some studies have found an increased prevalence in women[13 14], others have shown an increase in men[15 16] and, furthermore, other studies have found no gender- specific differences[17-19].

One reason for this lack of clarity might be that causes for MSD are multifactorial, for which awareness has risen in recent years[20]. Often both psychological and postural demands contribute to the development of MSD. Increasing competition and rising productivity requirements lead to increased pressure to meet deadlines and to perform[20], while the main working time is spent in offices in a static sitting position in front of a computer[21]. Both of these demands can lead to unphysiological tension of the musculature and, ultimately, contribute to restrictions in mobility[22].

Amongst other methods, such as resistance training, stretch trainings are a promising WHP approach, for which van Eerd et al.[23] found moderate evidence in a systematic review. The primary aim of stretch interventions is to improve mobility and, ultimately, to improve or prevent MSD. This was demonstrated, for example, in an investigation by Shariat et al.[24] who compared a stretch intervention to ergonomic adjustments in the office by means of the Cornell Musculoskeletal Disorders Questionnaire. While after four months' intervention time, both methods led to improvements in MSD (pain prevalence) in the lower back, shoulders and the

neck, after six months' intervention time, this improvement was only present in those subjects who had executed the stretching program.

However, the body of literature regarding stretching intervention for office workers is rather small as the subject is not, as yet, extensively studied[25]. For example, the programs investigated so far have scarcely been standardized and have not been individualized[24 26]. The stretching program "five-Business" ("Five Konzept", Hüfingen, Germany) allows stretching of the trunk on a specially designed device in different degrees of freedom. The training is short and can be done in work clothes. This training program has the prerequisites to be an effective means of promoting health in the office workplace.

Therefore, the aim of the present intervention control study with the "five-Business" training is to evaluate a standardized and, at the same time, individualized stretch program by means of the Nordic Questionnaire. In addition, existing gender differences and gender-specific effects of the intervention should be identified. This study is part of the OST project, which, in addition to MSD, investigates the effects of the "five-Business" program on the quality of life and mobility of office workers.

Methods

Subjects

Subjects were recruited among 1958 clerical employees of a German car manufacturer. A total of 252 participants successfully completed the study, while 61 subjects dropped out (IG=60; CG=1). A detailed description of the sample is given in Table 1.

Prior to the study we randomized in which department of the factory the intervention will take place. The following recruitment strategy consisted of an internal e-mail which was sent by the health department. Via an integrated link, employees could register for participation on a voluntary basis (Fig. 1); the registration deadline was set at two weeks. It was communicated that the training would be carried out during working hours and all participants were asked to pursue (only) their usual leisure activities during the intervention period. In close cooperation with the works council, the training was carried out during working hours. In order to provide all employees with the same opportunity to participate in an intervention during work hours, a waiting control group was included as part of the study design. In addition, a non-randomized allocation procedure based on availability was conducted to enable every employee to participate.

<Fig. 1>

Fig. 1: Disposition of study participants. Modified after Holzgreve et al. 2020[27]

Inclusion criteria included full-time employment in an office workplace, subjective health and freedom from exclusion criteria.

Exclusion criteria covered operations or surgical stiffening of the musculoskeletal system, relevant artificial joint replacement, serious diseases such as ankylosing spondylitis, chronic destructive joint diseases, multiple sclerosis, myodystrophic or neurodegenerative diseases, congenital malposition of the musculoskeletal system or acute diseases such as a herniated disc. In addition, the intake of muscle relaxants or other medications that influence the elasticity of the muscles, as well as pregnancy, were considered contraindicators. Further information can be found in the related methodology article[28].

All test persons gave a written declaration of consent to participate in the study in advance. The study was approved by the Ethics Committee of the Medical Faculty of the Baden-Württemberg Medical Association (F-2017-073).

Patient and Public Involvement

There were no patients involved in this study.

Intervention program "five-Business"

The device-supported stretch training “five-Business” (Fig. 2) is a WHP measure provided by the company "Five-Konzept" (Hüfingen/Germany). All exercises can be carried out standing, wearing shoes and in loose working clothes. Subjects held the five stretching positions twice for 20 seconds each. Further descriptions can be found in the methodology paper by Holzgreve et al.[28].

<Fig. 2>

Fig. 2: “The stretch training on the "five-Business" device. a) The device with the dimensions: 116 cm x 82 cm x 128 cm; weight: 60 kg, b) Exercise “Stand”, c) Exercise “Chest”, d) Exercise “Ischio”, e) Exercise “Hip” and f) Exercise “Lateral”.

Nordic Questionnaire

The Nordic Questionnaire records musculoskeletal complaints[29] and has been used internationally in a wide range of professions[30], including administrative professions[31]. The questionnaire asks for information about the person, their work situation and their 7-day, 12-month and lifelong prevalence of musculoskeletal complaints in the neck, shoulder, thoracic and lumbar spine and the joints of the extremities. The duration and frequency of the complaints, resulting impairments at work and participation in leisure activities, as well as physicians' consultations and incapacities to work, are recorded. The questionnaire was digitalized and completed online on site using computers provided for this purpose. The Nordic Questionnaire was provided in German and socio-demographic questions were additionally included.

Measurement protocol

The data presented here represent a partial evaluation of a larger exploratory research project - The office work and stretch training (OST) study - in which, in addition to MSD, the effects of the "five-Business" program on the health-related quality of life and mobility of office workers were investigated. Further details can be found in the related methodology article[28] and article on effects on the quality of life[27]. The intervention period covered 12 weeks, with data collection taking place in the week before and after the intervention. One training unit had a duration of about 10 minutes. During these 12 weeks, the subjects in the IG completed a total of 22-24 stretch training sessions, where possible twice a week. Prior to the study, participants were instructed not to start any new treatments during the intervention period. This did not apply to necessary treatments. In order to control for confounders each participant had to fill out a sports diary on every appointment. If new treatments that had an impact on the musculoskeletal system were started within the intervention period, this resulted in study

exclusion. In case of illness or holidays, absences of up to two weeks were granted, since this corresponds to the realistic conditions in everyday working life. The test persons were allowed to make up for the missed training sessions through a higher frequency of three training sessions per week. One training session lasted about ten minutes; each exercise was held twice for 20 seconds. The correct execution of the exercises was monitored by trained personnel via 1:2 supervisions. Progressive intensity was implemented by the trainers using the variable adjustment function of the device. If participants forgot their training dates, they were contacted and a catch-up date was arranged. In the waiting control group, the measurements were carried out analogous to the IG, but the subjects did not train on the "five-Business" device during the three months period. The Nordic Questionnaire was applied at baseline and after three months.

Statistical analysis

The sample size was calculated prior to the study. The calculations have been published in the related methodology article[28]. Gender differences have not been included in the calculation of the sample size. IBM SPSS Statistics 26 were used to perform the Kolmogoroff-Smirnoff-Liliiefors test to asses the normal distribution of the socio-demographic data. In order to obtain descriptive data, either means or medians including standard deviations (SD) or interquartile ranges (IQR), respectively, were calculated. The statistics of the Nordic Questionnaire measures were performed with BiAS (version 11.08), including only non-parametric methods, since the response options were dichotomized. For dependent comparisons, the McNemar test was performed. In order to test independent groups, the Chi^2 test with Yates-correction for case numbers <60 was used.

Results

In total, 313 participants (males: n=172; females: n=137) aged between 18 and 65 years volunteered to take part in the intervention control study. Of these, 216 were allocated to the intervention group (IG) and 97 to the waiting control group (CG). Two-hundred-fifty-two subjects (males: n=142; females: n=110) successfully finished the study (Tab 1). Adverse events due to treatment were almost none. One subject terminated participation due to thoracic spine discomfort. Final participants were 44 years (21) old, 175,3 cm (9.4) tall, weighted 76 kg (21) and had a BMI of 24.07 kg/m^2. More than two thirds of the subjects reported doing sports regularly for about 3 h per week (Tab. 1).

Tab. 1: Sociodemographic data of the entire sample. SD=standard deviation; IQR=interquartile range. The descriptive statistic is based on the data of the "final participants".

	Entire sample			**Intervention group**			**Control group**		
		male	female		male	female		male	female
Initial participants	n=313	n=172	n=137	n=216	n=135	n=78	n=97	n=42	n=55
Dropouts	n=61	n=36	n=27	n=60	n=34	n=23	n=1	n=1	n=0
Final participants	n=252	n=142	n=110	n=156	n=101	n=55	n=96	n=41	n=55
Age (years) median (IQR)	44 (21)	49 (15)	38 (21)	46,5 (17)	49 (14)	38,5 (22)	43 (23)	45 (22)	37 (18)
Height (cm) mean (SD)	175.3 ±9.4	180.4 ±7.4	168.8 ±7.5	176.2 ±8.7	180.7 ±9.5	167.9 ±6.3	173.9 ±10.4	179.9 ±9.9	169.6 ±12.4
Weight (kg) median (IQR)	76 (21)	82 (15)	65 (12.8)	77.5 (18)	82 (14)	65 (17.5)	71 (23)	82 (17.5)	65 (11.3)
BMI (kg/m^2) median (IQR)	24.07 (4.32)	24.79 (3.95)	23.12 (4.09)	24,34 (4.79)	24.93 (4.11)	23.12 (4.97)	23.53 (3.43)	24.57 (3.41)	23.10 (3.58)
Sports (% yes/% no)	71.8/ 27.4	71.8/ 27.5	71.8/ 27.3	71.2/ 28.8	70.3/ 29.7	72.7/ 27.3	72.9/ 25.0	75.6/ 22.0	70.9/ 27.3
Smoking (% non-smoker)	87.7	90	86.4	89.7	92.1	85.5	87.1	84.6	88.9
h/sports/week median (IQR)	3 (3)	3 (4)	2 (2)	2 (4)	2 (4)	2 (3)	3 (3)	4 (3)	3 (3)

In the entire sample at baseline the participants reported the most complaints for the last year in the areas of the neck (60.66%), shoulders (51.02%) and lower back (48.37%). More than a quarter of the participants stated that they had had complaints in the upper back (25.73%) and knees (26.42%) in the last year (Fig. 3).

<Fig. 3>

Fig. 3: 12-month prevalences of MSD in [%] of the entire sample at baseline.

The calculations of the McNemar test showed that in the IG the proportion of participants with complaints in the neck ($p<0.001$), shoulders ($p<0.02$), upper back ($p<0.001$) and lower back ($p<0.01$) had significantly decreased post-intervention (Fig. 4). In the thighs (16.89% vs. 12.16%), the wrists/hands (17.57% vs. 13.33%) and the knees (33.55% vs. 26.67%), a non-significant trend of a reduction in complaints was observed (Fig. 4). For the CG, significant differences in pain prevalence could be detected in the neck after 12 weeks compared to the

baseline (p=0.41). Moreover, a non significant reduction in complaints was evident in the area of the shoulders (42.11% vs. 36.46%), lower back (37.23% vs. 34.74%) and thighs (11.83% vs. 8.42%).

<Fig. 4>

Fig. 4: Pre-post comparison of the 12-month prevalence of MSD in [%] in the intervention and control groups**.** IG = intervention group; CG = control group. Significant differences are marked with asterisks for p<0.05 = "*", p<0.01 = "**" and p<0.001 = "***".

Gender effects

With the exception of the elbow and lower back, female office workers showed a generally higher 12-month prevalence of musculoskeletal complaints at baseline (Fig. 5). Both male and female workers had the most complaints in the shoulder/neck area and in the lower back. In almost all areas and in both genders, musculoskeletal pain prevalences decreased after the intervention; this was especially observed in the most heavily affected regions where the employees seemed to benefit particularly from the intervention. It can also be seen that in almost every region, the pain prevalence rates of both sexes were converging. Gender specific significant differences were found for the neck area between baseline prevalences (p<0.001) and between baseline and post-intervention (p<0.001) in females. Further significant differences were found in the upper back area. Both males (p=0.041) and females (p=0.007) had significant reductions of complaints. Moreover, males had significantly (p=0.011) less back pain after the intervention. In addition, females reported at baseline significantly more often about foot complaints (p=0.015) than males (Fig. 5).

<Fig. 5>

Fig. 5: 12-month prevalence of MSD in [%] at baseline and after intervention, according to gender, for the neck, shoulder, elbow, wrist, upper back, lower back, hip, knee and foot area. Significant differences are marked with asterisks (p<0.0 = "*", p<0.01 = "**" and p<0.001 = "***"). For dependent variables, the NcNemar test was applied; for independent variables, Chi^2 with Yates-correction for n<60 was used.

Discussion

The aim of the study was to examine the effectiveness of the "five-Business" stretch training in reducing MSD concerning the 12-month prevalence among office workers. In addition, gender differences were also identified with regard to the research objective. The results showed a significant reduction in the 12-month prevalence of MSD, following a 3-month stretch training program, in the area of the neck, shoulders, upper and lower back and the feet (Fig. 4) in the treatment group. Since these were also the body parts most affected in the baseline results, the reduction in complaints occured in exactly those areas that are exposed to risk factors for MSD from sedentary and static activities[9 10] (Fig. 3 & 4).

The prevalences found are in line with current literature[3 32-34] investigating MSD among office workers. Kalieniene et al.[33] found neck pain in 65.7%, shoulder pain in 50.5% and low back pain in 56.1% in a sample of public service computer workers in Lithuania; a similar distribution of complaints was shown in Australian office workers with prevalences of 76% (neck), 71% (shoulders) and 65% (lower back)[32]. Less complaints, but similar affected areas, have been reported in office workers in Bangladesh[3] and Iran[34].

Regarding the stretch trainings as a method to reduce MSD, the few previous studies confirm the current findings[23 25 35]. For example, Tunwattanapong et al.[26] conducted a daily neck and shoulder stretching program for four weeks in office workers with moderate to severe neck or shoulder pain. The treatment group showed a significant decrease in neck and shoulder pain and an improvement in neck function and in the physical dimensions of the SF-36 questionnaire. Similar results have been shown in the present study since, here too, especially in the neck and shoulder area, the treatment group showed great improvements (Fig. 4).

Furthermore, the positive effects on low back pain are also supported by the findings of Lawand et al.[36], who showed significant improvements in pain, function and some quality of life aspects in patients with chronic low back pain. In this randomized controlled trial, subjects performed a weekly 60-minute stretching program, according to the global postural re-education method, over 12 weeks. The intervention period is similar to this study, but with longer stretching sessions. However, in the current study, significantly less office workers reported pain in the lower back area (12.78%).

The results of the current study also showed significant reductions of pain prevalence in the upper back and feet, with reduction trends observed in the wrists, thighs and knees, indicating that this whole body stretching program is effective in most areas of the body.

In the control group no difference between baseline and post was observed, except for the neck area ($p<0.05$). This unspecific effect may be due to various reasons; for example, the company's appreciation of the employees or the fact that skilled trainers took care of the particpants may have led to this.

Gender-specific significant differences were obtained at baseline in the area of the neck (f: 86.62% vs. m: 57.29%) and the feet (f: 25.45% vs. m: 10.42%) with significant treatment effects observed among males in the upper and lower back and among females in the neck and lower back, respectively (Fig. 5).

Fundamentally, the results show that women are more likely to report having MSD than men which is in line with the existing evidence[11]; this is especially noticeable in the neck (+29.5%), shoulder (+12.73%) area and upper back (+11.59%) where women seem to be more frequently affected than men (Fig. 5). These results confirm the contemporary literature that upper extremities MSD and neck/shoulder pain are predominantly found in women[12]. The exception to this point is the lower back, with 9.53% more men affected. According to the current state of knowledge, the evidence is unclear concerning gender-specific differences[10]. In principle, employees seem to benefit particularly in the regions that are most affected. According to this, women benefit particularly in the neck ($p<0.001$) and men in the lower back ($p<0.05$). In both groups, a significant reduction in upper back complaints ($p<0.05$ in males, $p<0.01$ in females) was also observed. In the area of the shoulders, which was frequently reported, a clear trend can be seen in both sexes (-9.22% in males, -14.81% in females). It is particularly striking that both the significant regions and the trends after the intervention appeared to be converging. In summary, it can be stated that women in the office workplace generally suffer more frequently from MSD. However, both men and women benefited from the stretching program.

The study results showed that a device-supported standardized and individualized stretch training is suitable as a WHP measure.

When interpreting the presented results, the lack of randomization has to be taken into account. A randomized allocation to the study groups was not possible due to the organizational structure of the company. However, the aim of this study was to investigate the effects of a WHP program deliberately in the field. In our opinion, this also represents the strength of this study. It was carried out under realistic working conditions with the involvement of the works council within the framework of the employees' working hours on a voluntary basis. Furthermore, such WHP programs are usually applied in large companies, where cooperation with the works council is essential. Any other approach would have been simply not being possible in this case. In addition, subjects had to arrange training in accordance with business appointments and holidays, randomization would have threatened the feasibility of this study. This might also explain differences in the group size and gender distribution between the intervention and control group. Furthermore, we were not allowed to randomize selection among participants because of the intervention by the works council and legal department and their concerns about data protection.

In addition to the survey of pain prevalences, an investigation of the days and main causes of sick leave would have been useful. Unfortunately, this was not approved by the works council.

Furthermore, it has to be emphasized that the participants were guided by experienced trainers throughout the three months' intervention time. When implementing five business as a WHP program, an introduction of all employees with regular control appointments is recommended to ensure technically correct execution. Constant monitoring of the training is not necessary. The trainers also arranged new training appointments if subjects missed their session. It is doubtful that participation would have been sufficiently regular without the personal supervision of a trainer. In the framework of the OST project Holzgreve et al.[27] could already show that the stretching intervention has relevant effects on the quality of life. In particular, strong effects were found in the psychological component of the quality of life. With regard to the main causes (MSD and mental illness) of sick leave in Germany, the "five-Business" program seems to be a suitable measure for prevention and therapy in the context of health promotion for office workers.

Future studies should aim to implement a follow-up evaluation in order to investigate whether the stretch training can reduce MSD and days of incapacity to work in the long term and evaluate the effects of different intervention periods and training frequencies.

Conclusion

The results suggest that a stretching program performed for three months can reduce musculoskeletal complaints in the most affected areas in office workers. Both men and women benefited from the stretch training to a similar extent. Concerning the ubiquitous prevalence of MSD in office workers, especially shoulder/neck pain, upper back pain and lower back pain, the stretch program is proposed to be a promising measure for the therapy and prevention of MSD as part of workplace health promotion.

Declarations

Author's contribution

A.v.M., H.S., M.F., A.B. and D.O. conceived the original idea.
A.v.M., D.O., F.H., L.M. and J.H. conceived and planned the experiments.
F.H., L.M. and J.H. carried out the experiment.
D.O., A.v.M., D.A.G., H.S., A.B. and M.F. helped supervise the Project.
F.H. wrote the manuscript with support from L.M., D.A.G., A.v.M. and D.O.
All authors discussed the results and contributed to the final manuscript.

Competing interests

None declared.

Funding

No funding was obtained for this study.

Data Sharing Statement

Not applicable.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Medical Faculty of the Baden-Württemberg Medical Association (F-2017-073). All participants signed an informed consent to participate in advance, so the consent was written. Minors were excluded as participants of this study.

Consent to publish

Not applicable.

Cohort Description

Patients were not involved in this study.

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Figure legends

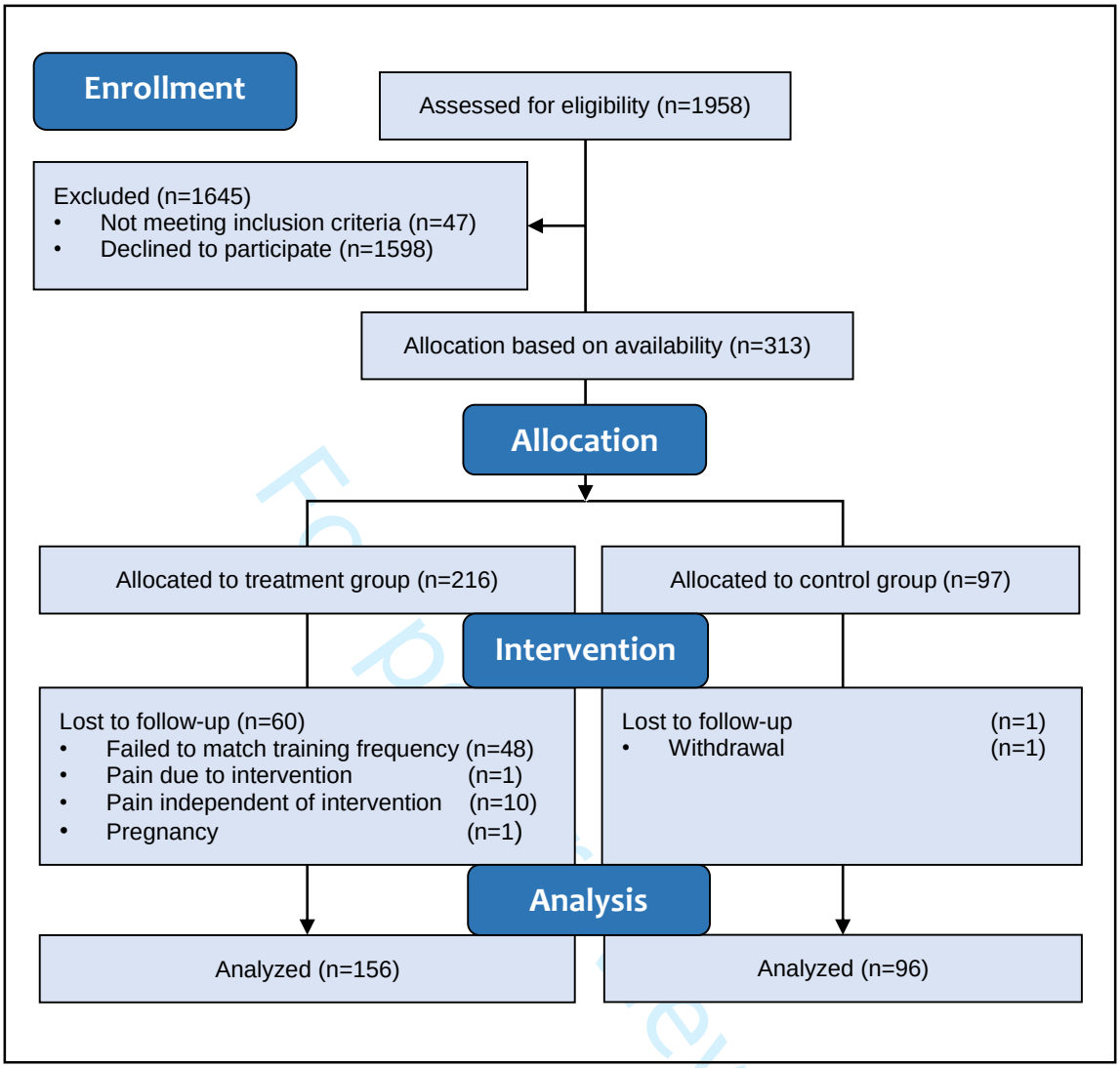
Fig. 1: Disposition of study participants. Modified after Holzgreve et al. 2020[27]

Fig. 2: "The stretch training on the "five-Business" device. a) The device with the dimensions: 116 cm x 82 cm x 128 cm; weight: 60 kg, b) Exercise "Stand", c) Exercise "Chest", d) Exercise "Ischio", e) Exercise "Hip" and f) Exercise "Lateral".

Fig. 3: 12-month prevalences of MSD in [%] of the entire sample at baseline.

Fig. 4: Pre-post comparison of the 12-month prevalence of MSD in [%] in the intervention and control groups**.** IG = intervention group; CG = control group. Significant differences are marked with asterisks for $p<0.05$ = "*", $p<0.01$ = "**" and $p<0.001$ = "***".

Fig. 5: 12-month prevalence of MSD in [%] at baseline and after intervention, according to gender, for the neck, shoulder, elbow, wrist, upper back, lower back, hip, knee and foot area. Significant differences are marked with asterisks ($p<0.0$ = "*", $p<0.01$ = "**" and $p<0.001$ = "***"). For dependent variables, the NcNemar test was applied; for independent variables, Chi^2 with Yates-correction for $n<60$ was used.



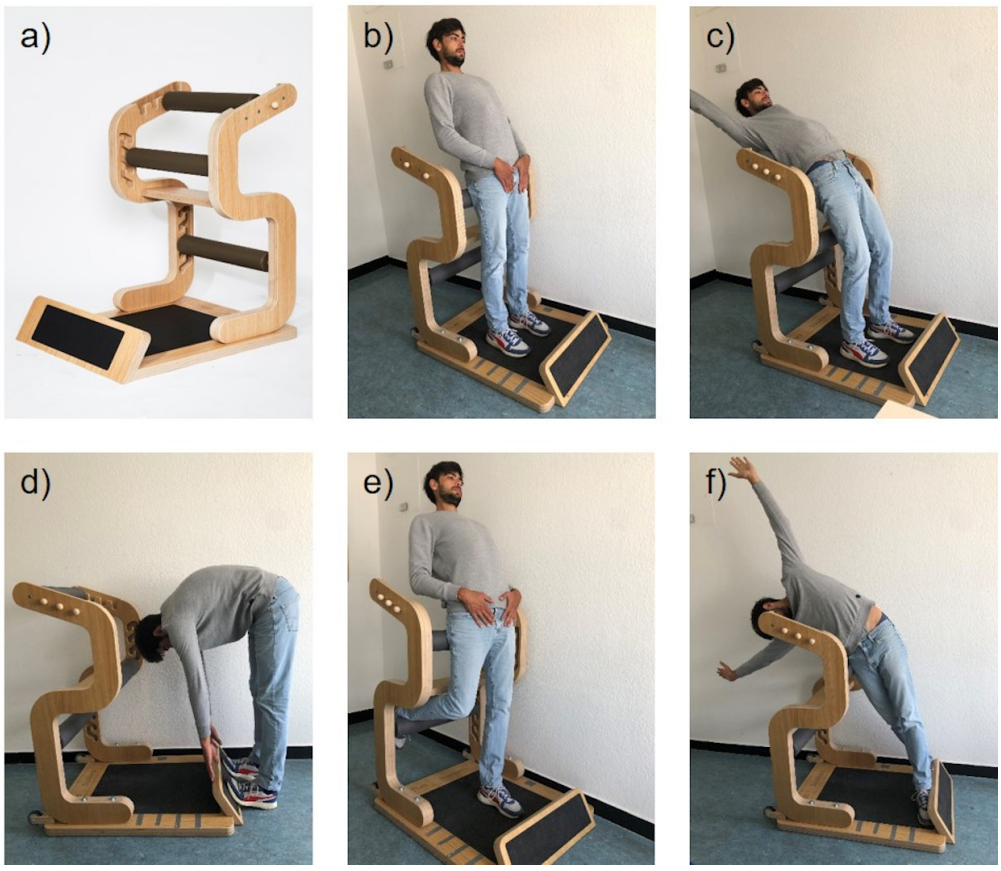


Fig. 2: "The stretch training on the "five-Business" device. a) The device with the dimensions: 116 cm x 82 cm x 128 cm; weight: 60 kg, b) Exercise "Stand", c) Exercise "Chest", d) Exercise "Ischio", e) Exercise "Hip" and f) Exercise "Lateral".

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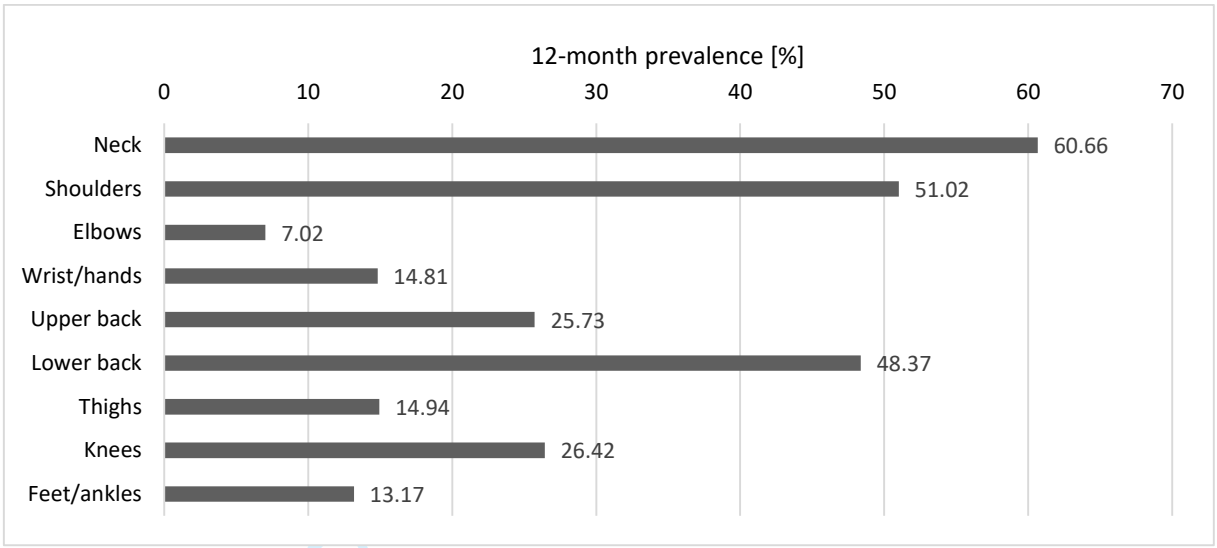

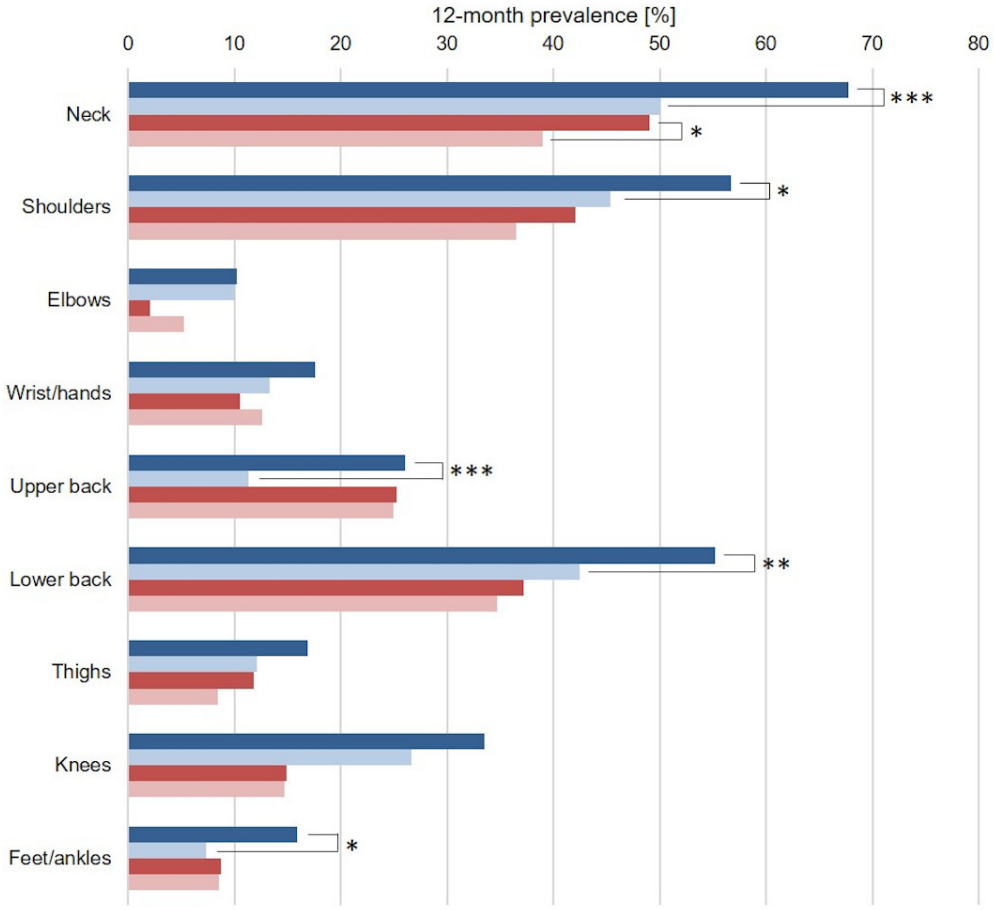

	Neck	Shoulders	Elbows	Wrists/hands	Upper back	Lower back	Thighs	Knees	Feet/ankles
IG_baseline	67.79	56.67	10.20	17.57	26.03	55.26	16.89	33.55	15.89
IG_post	50.00	45.39	10.00	13.33	11.33	42.48	12.16	26.67	7.38
CG_baseline	49.00	42.11	2.11	10.53	25.26	37.23	11.83	14.89	8.70
CG_post	39.00	36.46	5.21	12.63	25.00	34.74	8.42	14.74	8.51

Fig. 4: Pre-post comparison of the 12-month prevalence of MSD in [%] in the intervention and control groups. IG = intervention group; CG = control group. Significant differences are marked with asterisks for $p<0.05$ = "*", $p<0.01$ = "**" and $p<0.001$ = "***".

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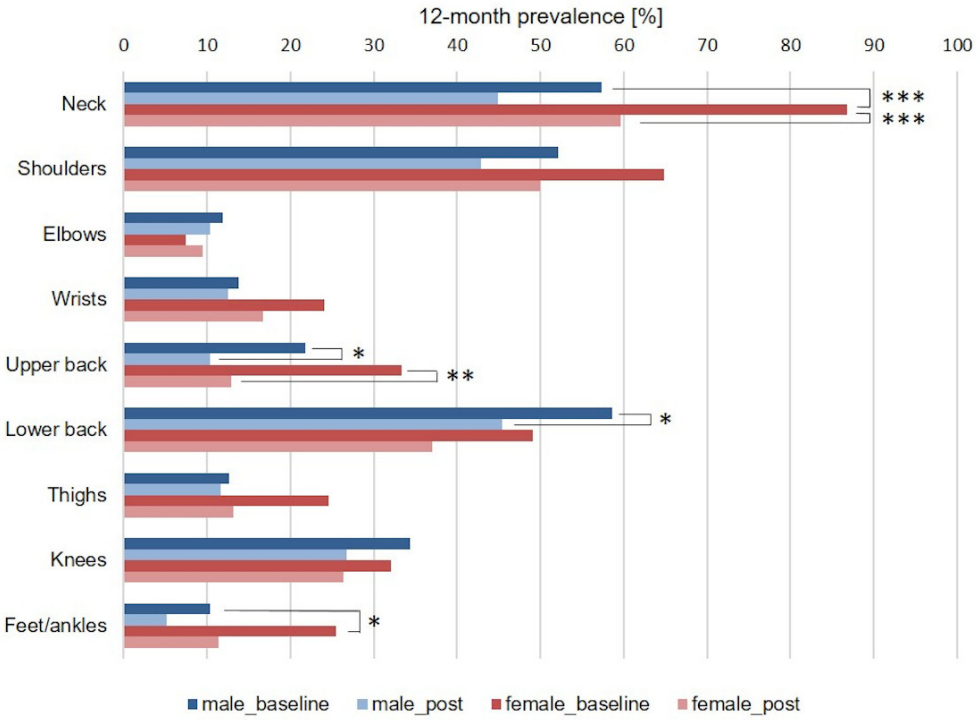

	Neck	Shoulders	Elbows	Wrists/hands	Upper back	Lower back	Thighs	Knees	Feet/ankles
male_baseline	57.29	52.08	11.83	13.83	21.74	58.59	12.63	34.34	10.42
male_post	44.90	42.86	10.31	12.50	10.42	45.45	11.58	26.80	5.21
female_baseline	86.79	64.81	7.41	24.07	33.33	49.06	24.53	32.08	25.45
female_post	59.62	50.00	9.43	16.67	12.96	37.04	13.21	26.42	11.32

Fig. 5: 12-month prevalence of MSD in [%] at baseline and after intervention, according to gender, for the neck, shoulder, elbow, wrist, upper back, lower back, hip, knee and foot area. Significant differences are marked with asterisks (p<0.0 = "*", p<0.01 = "**" and p<0.001 = "***"). For dependent variables, the NcNemar test was applied; for independent variables, Chi2 with Yates-correction for n<60 was used.

94x90mm (300 x 300 DPI)